NCTCOG Regional Travel Model Improvement Experience in 2009

Travel Model Development
and
Data Management

Presented to

TMIP VMTSC

North Central Texas Council of Governments

December 7, 2009

Presenters

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Content

- Previous TMIP-VM presentation by NCTCOG in March 2009
- Data Sources for Model Improvements
- Improved Model Components
- Estimation, Calibration, and Validation

Previous TMIP-VM NCTCOG Presentation

→ March 13, 2009 Topics

- Front-end of the Regional Travel Model
  - Travel model application software (DFWRTM, DFX)
- Data Collection and Maintenance
  - Data management program examples
  - Transit surveys
- Model Components Design and Improvements
  - Described model structure
  - Introduced improvement components in traffic assignment and feedback process
  - We will expand major model improvements, reasons behind their selection, the building processes, and performance

Data Sources for Model Improvements

→ TxDOT Daily Traffic Counts for 2004

- 5 year program
- Purpose is HPMS
- We receive the daily count by location
- Data clean up is a major task
  - Identification of wrongly coded counts is difficult
  - Once identified, correction method is per case
  - Systematic identification of errors is not practical
  - Point of comparison does not exist
  - Therefore, clean up is never over!
  - Neither is calibration/validation

Data Sources for Model Improvements

→ Daily Counts From Other Sources 2004+

- Cities, counties, airports, and toll authorities in many formats
- Geo-coded and put in the data base
- Quality control issues are similar to TxDOT counts

→ Counts and speeds from other NCTCOG sponsored projects

- Arterial counts and travel time studies on more than 100 corridors by time of day
- Toll road travel time studies on freeways
- All geo-coded and put in the database system

Data Sources for Model Improvements

→ Transit Data
- 3 transit onboard surveys in 2007 and 2008 (in previous session)
- Daily boarding data for all transit lines for 2007 and 2008

- External Trip Data
- 2005 survey
- 2005 counts

Improved Model Components

→ Roadway Model
- Assignment convergence criteria
- Developed new volume-delay function
- Model calibration
- Developed New Feedback convergence criteria

→ Transit Model
- Used transit onboard surveys
- Developed new transit network model
- Developed new vehicle ownership model
- Developed new mode choice model

Roadway Model

Assignment Convergence Criteria

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Assignment Convergence Issue

→ The DFWRTM performs a UE assignment in TransCAD with a convergence criteria of 30 iterations.

→ This process created some level of noise in the model results. Noise is the difference in link volumes between the Ideal User Equilibrium and the traffic assignment performed in DFWRTM.

Assignment Convergence Issue

→ Study objective :

- are 30 iterations enough to reach stable volumes on all links?

→ Study goals :

- how the convergence criteria could be changed to :
  - reduce the RMSE from an ideal User Equilibrium;
  - reduce the model noise level; and
  - maintain a reasonable model run time.

Assignment Convergence Study

→ Test scenarios :

- 30 iterations
- 0.002 relative gap
- 0.001 relative gap
- Ideal User Equilibrium

→ Comparison measures :

- RMSE
- Assignment Run Time
- Noise reduction for a controlled change

RMSE Comparison*

Scenario	1999	2007	2009	2025	2030	**Average**
30 iterations	5.39	4.63	4.45	4.67	4.16	**4.66**
0.002 RG	1.98	1.87	1.39	1.39	0.96	**1.52**
0.001 RG	1.25	0.87	0.99	1.39	0.88	**1.08**
Ideal UE	0.00	0.00	0.00	0.00	0.00	**0.00**

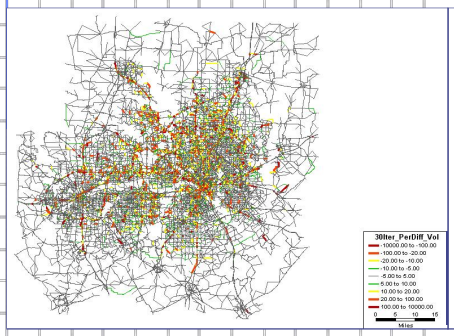
* RMSE between the analyzed scenario and the Ideal UE.

Assignment Run Time Comparison

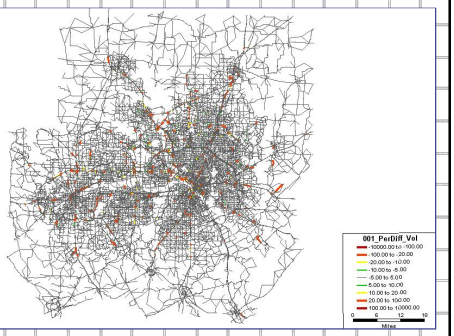
Scenario	1999		2007		2009		2025		2030	
	Iteration	Run Time	Iteration	Run Time	Iteration	Run Time	Iteration	Run Time	Iteration	Run Time
30 iterations	30	0:47	30	0:50	30	0:58	30	1:05	30	1:08
0.002 RG	83	2:10	69	1:31	85	2:49	81	2:57	93	2:34
0.001 RG	126	3:16	124	2:45	113	3:43	81	2:58	102	2:47
Ideal UE	575	14:55	180	3:57	207	6:28	155	4:12	107	2:55

Comparing % Link Flow Change

30 Iterations



.001 Relative Gap



Travel Model Development

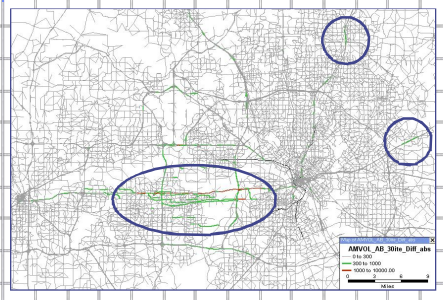
Controlled Change – Link Volumes

Reduced 2 lanes on EB IH 30 :

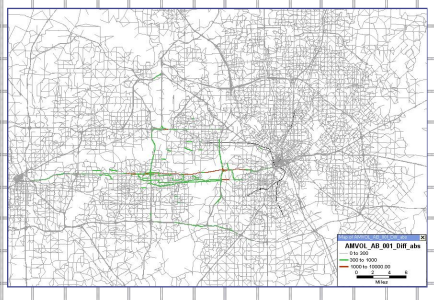
→ Expect traffic on EB IH 30 to decrease

→ Expect ramp volumes to change

30 Iterations



.001 Relative Gap

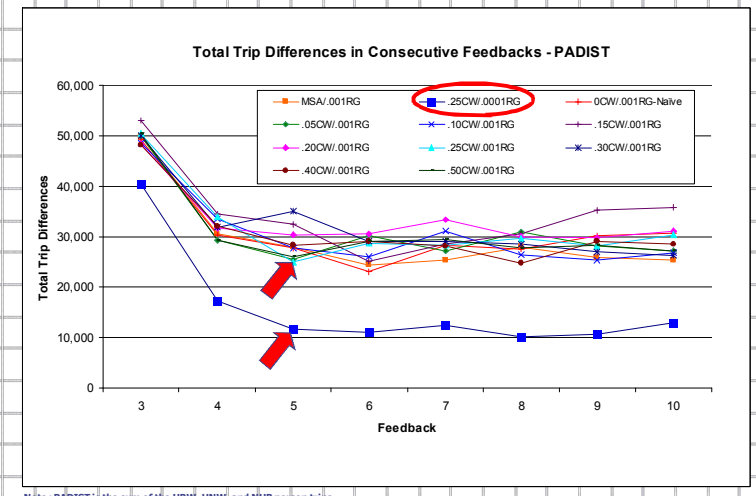


Traffic Assignment Conclusions

Choose .001 relative gap :

- Reduced RMSE to 1%
- Significantly reduced noise from 30 iterations
- Is more affordable time than ideal UE since the time for an assignment could reach up to 14 hours.

Feedback Test Results



Note : PADIST is the sum of the HBW, HNW, and NHB person trips

Feedback Tests Conclusions

After implementation of Feedback loops, a relative gap of .001 was found to not have a desirable network level convergence.

Therefore, a .0001 relative gap was selected in the model application.

Roadway Model

Volume-Delay Function

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Goals

→ Provide the Capability to :

- reach equilibrium
- remove minimum speeds
- incorporate traffic control delay
- reduce model noise
- incorporate HCM concepts in calculating capacity and traffic-control delay, if practical

Approach

→ Data availability :

- limited speed and travel time data
- no concurrent speed and volume data

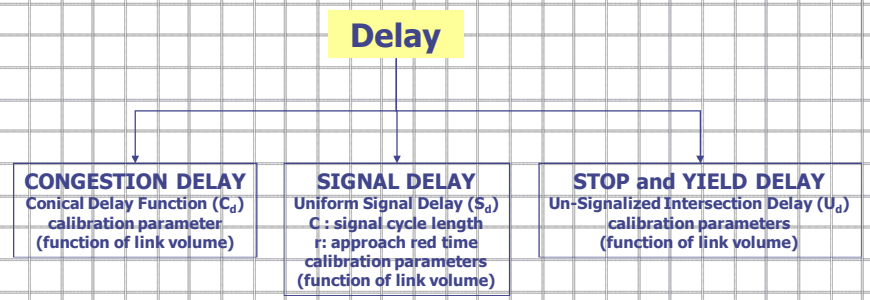
→ VDF Development :

- start from scratch (not from previous VDF)
- develop the VDF concepts
- formulate and implement the VDF
- maximize use of available data

VDF Improvements

Item	1999	2004 Expanded
Travel Time	Post-Processing VDF	Assignment VDF
VDF Form	NCTCOG (w/ minimum speed)	CONICAL (w/ Traffic Control Delay Function)
Traffic Control Delay	Static (not a function of v/c)	Dynamic (function of v/c)

Modified VDF



VDF – Congestion Delay

→ Exponential Congestion Delay Function :

$$TravelTime = FreeFlowTime + Min\{A.e^{B.(vol/cap)}, C\} * Length$$

→ Conical Congestion Delay Function :

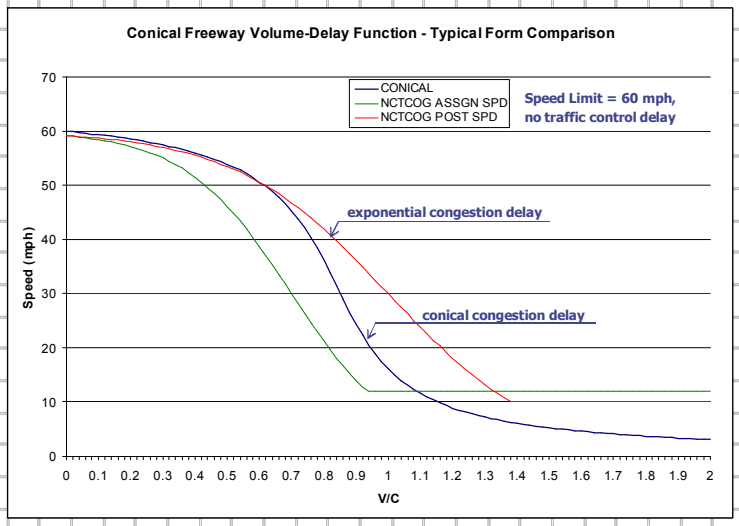
$$C_d = T_0 * (K_d - \{K_d \mid \frac{v}{c} = 0\})$$

$$K_d = \left(1 + \sqrt{A\_CONICAL^2 * (1 - \frac{v}{c} + dx)^2 + B\_CONICAL^2} - A\_CONICAL * (1 - \frac{v}{c} + dx) - B\_CONICAL\right)$$

$$B\_CONICAL = \left(\left[\frac{(2 * A\_CONICAL - 1)}{(2 * A\_CONICAL - 2)}\right]\right)$$

Travel Model Development

Freeway VDF Comparisons



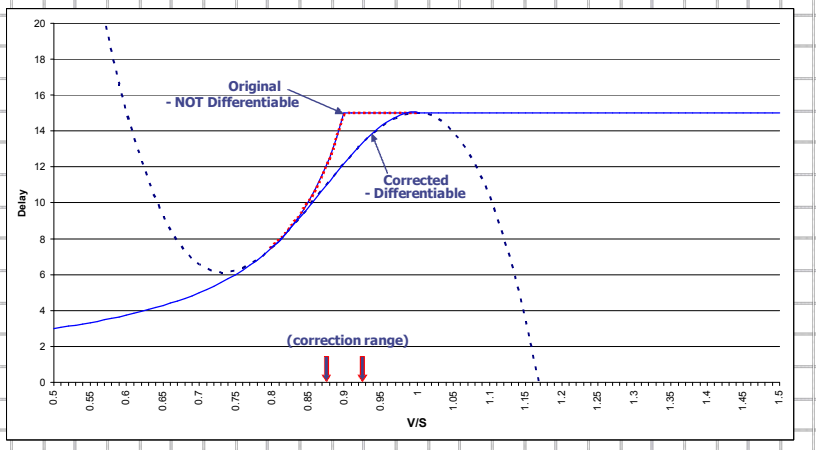
Travel Model Development

VDF – Signal Delay

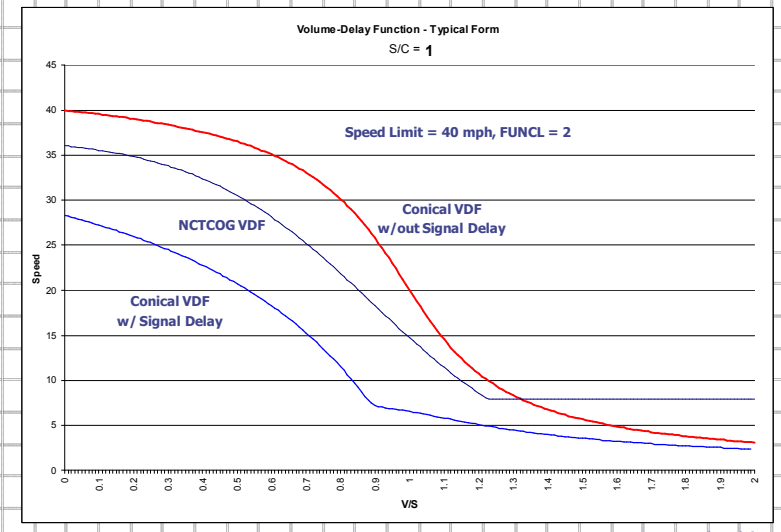
→ Webster's uniform delay :

$$S_d = \begin{cases} \left[\dfrac{PARAM\_SIG}{MAX\left(1-\frac{v}{S},L\right)}\right] & , PARAM\_SIG > 0,\ 0 \le v/s \le L_1 \\ CA*\left(\frac{v}{S}\right)^3 + CB*\left(\frac{v}{S}\right)^2 + CC*\left(\frac{v}{S}\right) + CD & , PARAM\_SIG > 0,\ L_1 < v/s < L_2 \\ \left[\dfrac{PARAM\_SIG}{MAX\left(1-\frac{v}{S},L\right)}\right] & , PARAM\_SIG > 0,\ v/s \ge L_2 \\ 0, \text{ otherwise} \end{cases}$$

VDF – Signal Delay

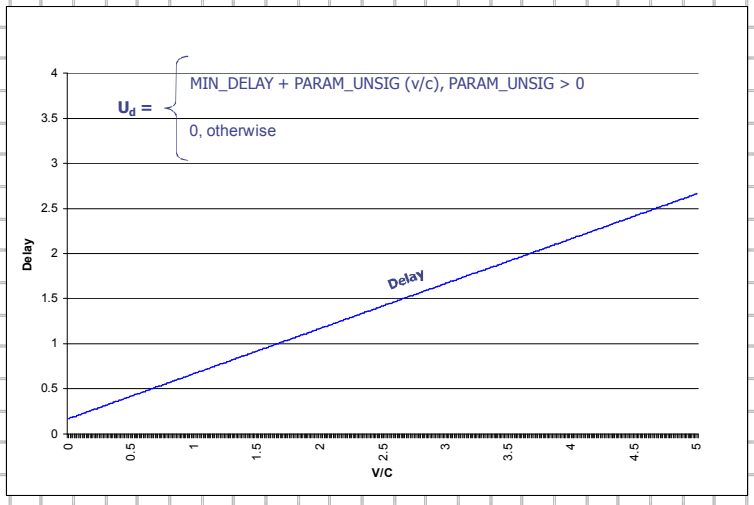


VDF + Signal Control – Arterial



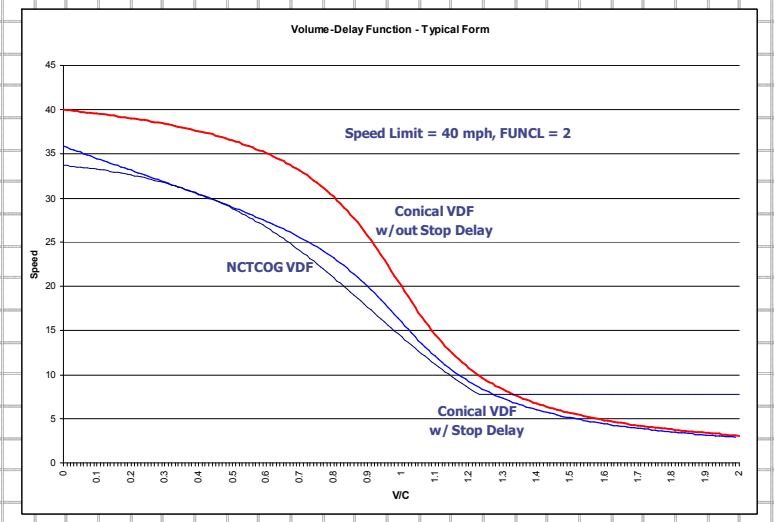
Travel Model Development

Modified VDF – Unsignalized-Control Delay



Travel Model Development

VDF + Stop Control – Arterial



Travel Model Development

Roadway Model

Calibration Results

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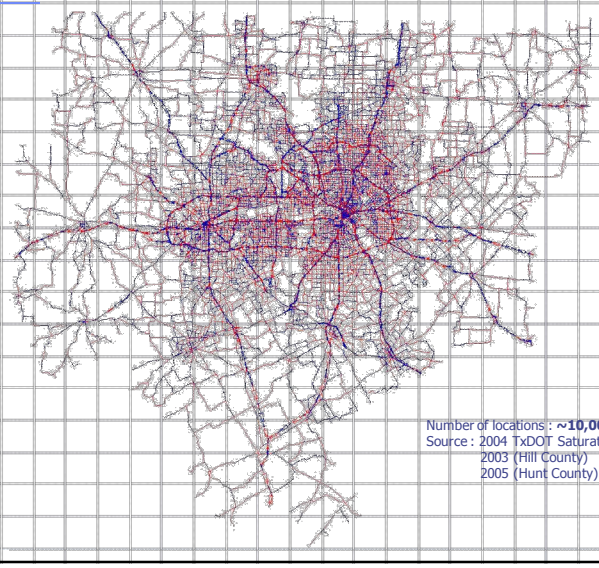
Location of Traffic Counts



Number of locations : **~10,000**
Source : 2004 TxDOT Saturation Counts
2003 (Hill County)
2005 (Hunt County)

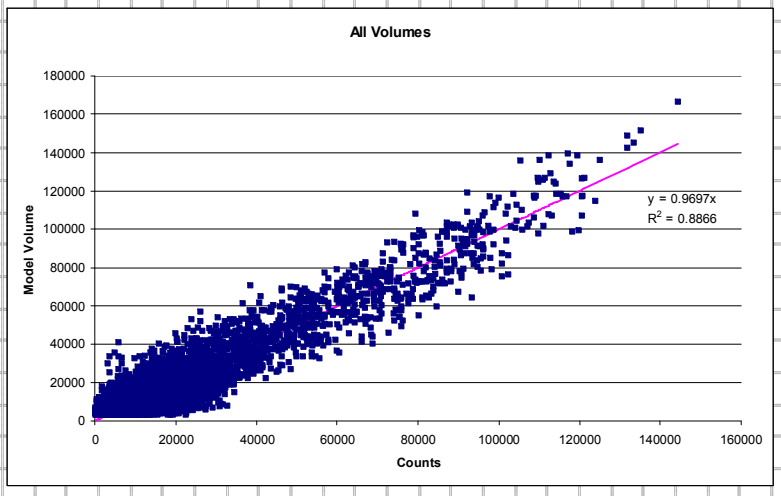
Model RMSE Comparisons

FUNCL	DFWRTM 1999			Expanded 2004		
	RMSE	% F/C	# OBS	RMSE	% F/C	# OBS
1	15.36	+2.09	885	18.16	0.00	1,113
2	30.80	-0.16	1,156	40.77	-1.00	1,413
3	38.46	-13.55	2,630	45.74	-7.00	2,696
4	55.07	-24.47	2,087	60.94	-2.00	1,378
6	49.05	-13.07	33	51.11	+2.00	1,406
7	55.18	-11.58	308	66.11	+5.00	257
ALL	32.28	-6.87	7,099	36.92	-2.00	8,263

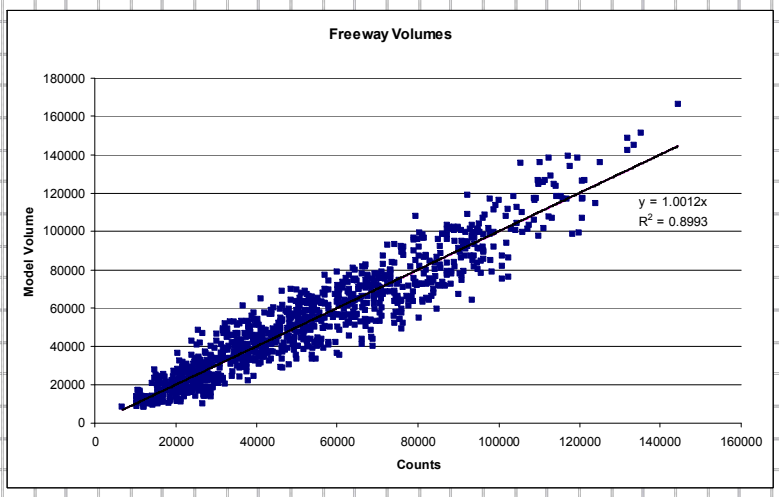
Link RMSE Comparisons

Daily Traffic Count (vpd)	%RMSE 2004 Expanded
> 50,000	15.17
25,000 ≤ X < 50,000	29.68
10,000 ≤ X < 25,000	38.08
5,000 ≤ X < 10,000	57.65
X < 5,000	70.95
ALL	36.92

Model Volumes



Freeway Volumes



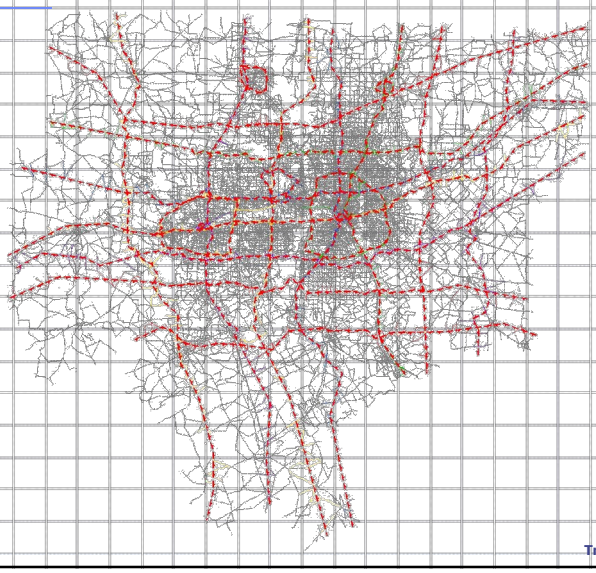
Travel Model Development

Freeway Corridors RMSE Comparisons

Freeway	%RMSE 1999	% RMSE 2004 Expanded
I30 WB	9.22	18.24
I30 EB	9.30	
I20 WB	27.14	22.58
I20 EB	25.01	
I35W SB	17.44	20.74
I35W NB	15.98	
I35E SB	8.84	17.91
I35E NB	10.38	
US 75 SB	22.98	11.09
US75 NB	22.78	
I635 WB	11.57	11.69
I635 EB	11.59	
I635 SB	5.73	
I635 NB	8.96	
SH360 SB	17.42	16.90
SH360 NB	19.15	
I45 SB	26.53	18.84
I45 NB	26.53	

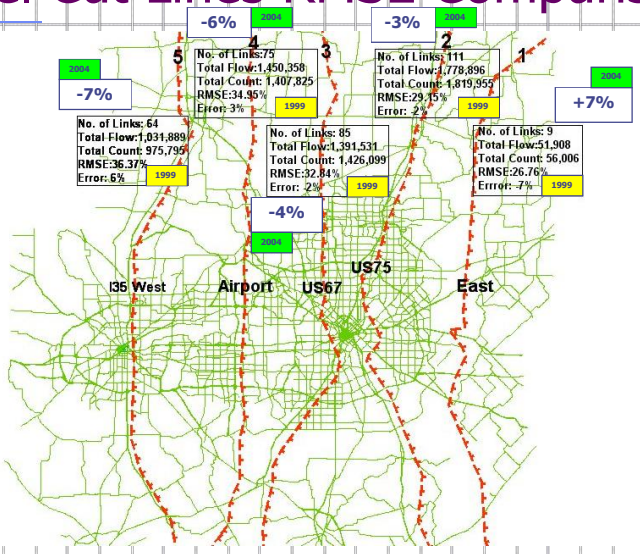
Travel Model Development

Model Cut Lines



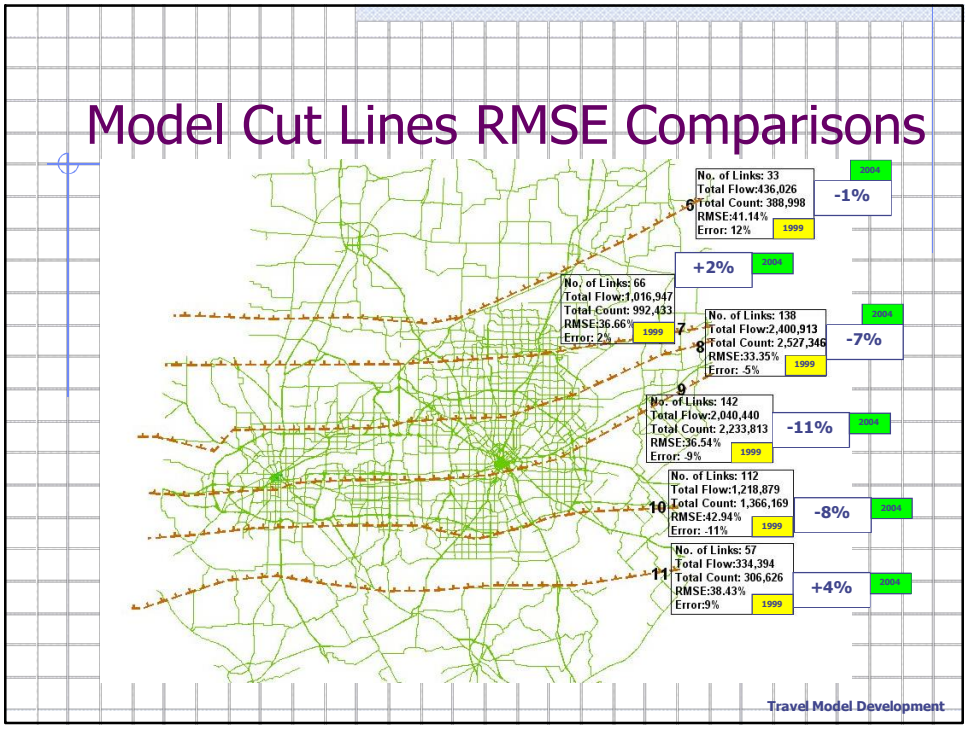
Travel Model Development

Model Cut Lines RMSE Comparisons

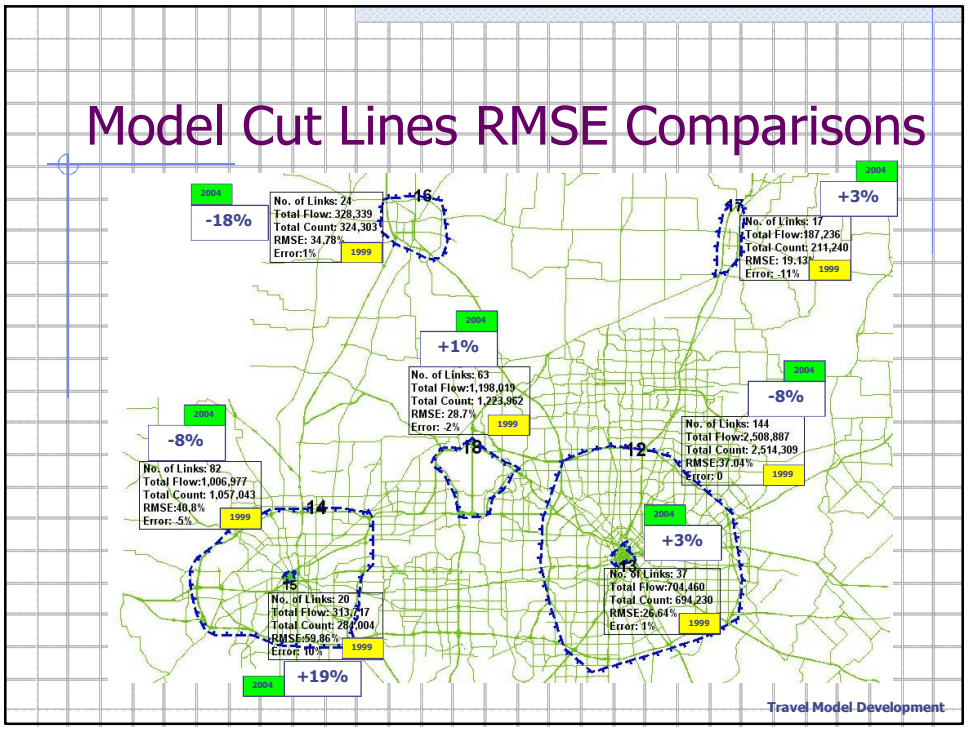


Travel Model Development

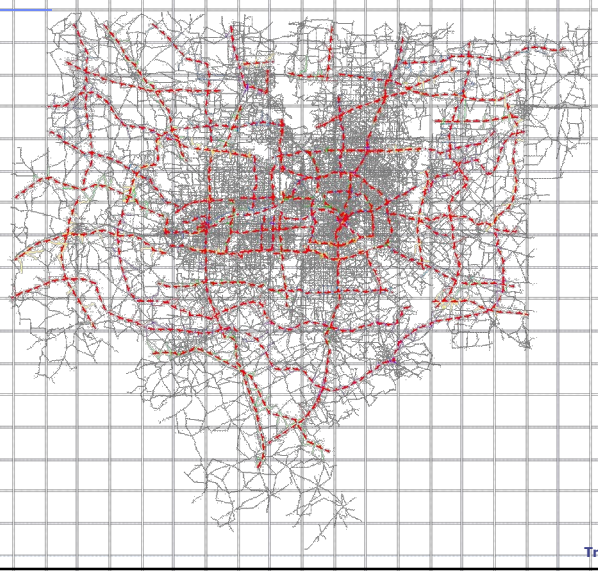
Model Cut Lines RMSE Comparisons



Model Cut Lines RMSE Comparisons

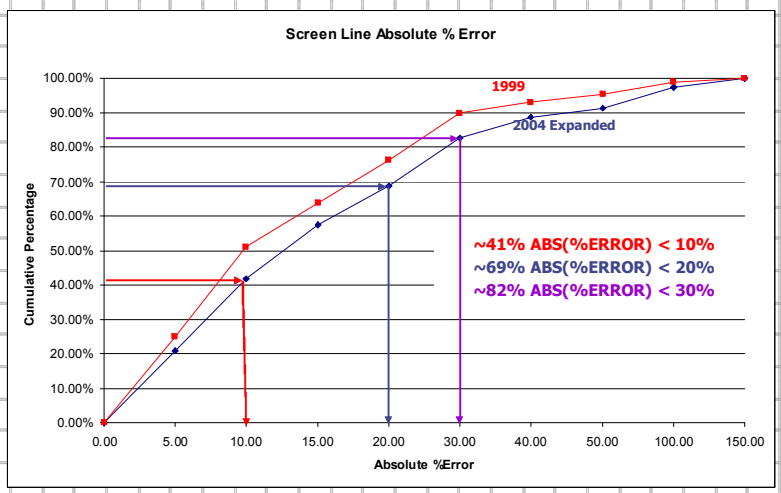


Model Screen Lines



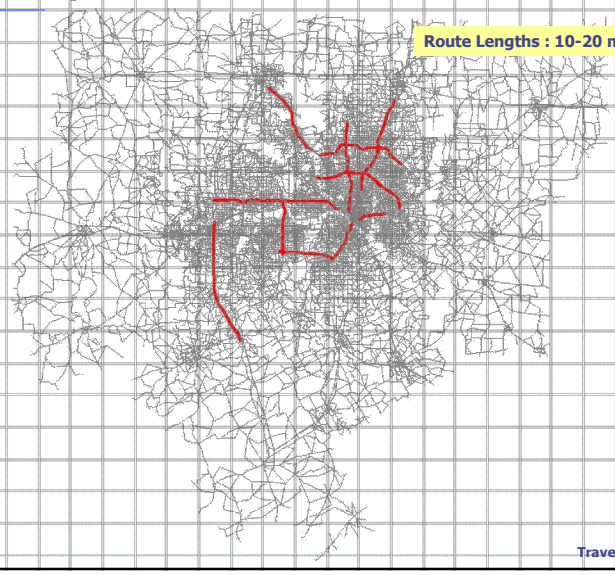
Travel Model Development

Model Screen Lines %Error

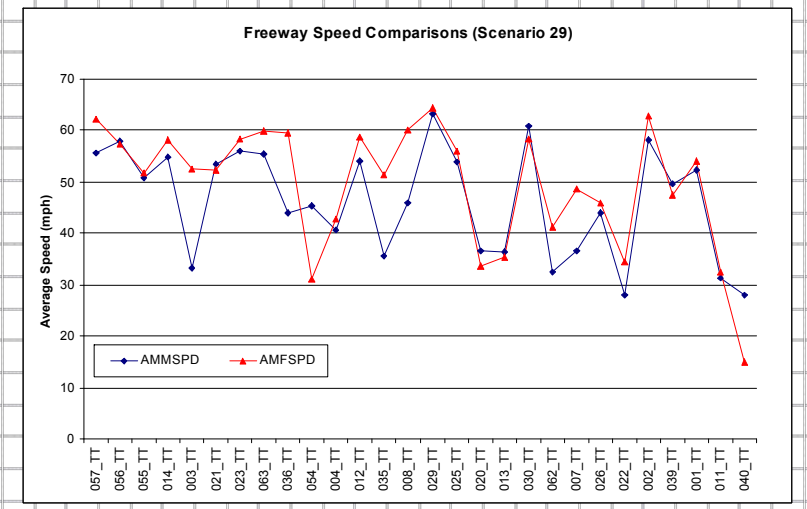


Travel Model Development

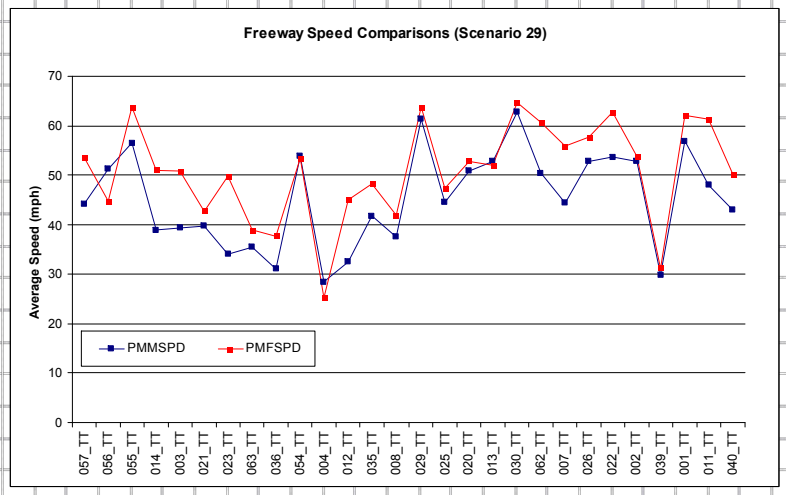
Freeway Travel Time Database



Freeway Speed Comparisons - AM

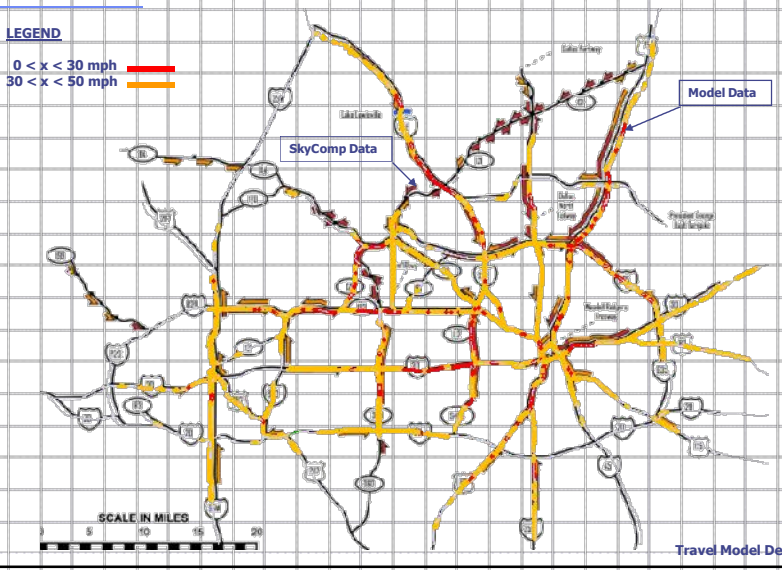


Freeway Speed Comparisons - PM



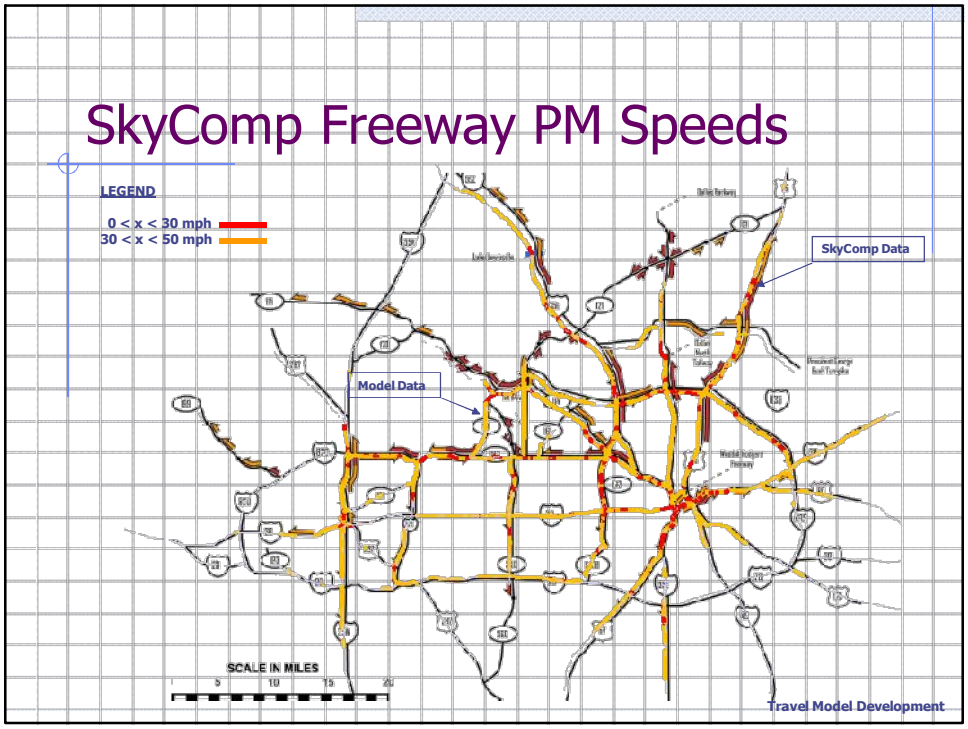
Travel Model Development

SkyComp Freeway AM Speeds

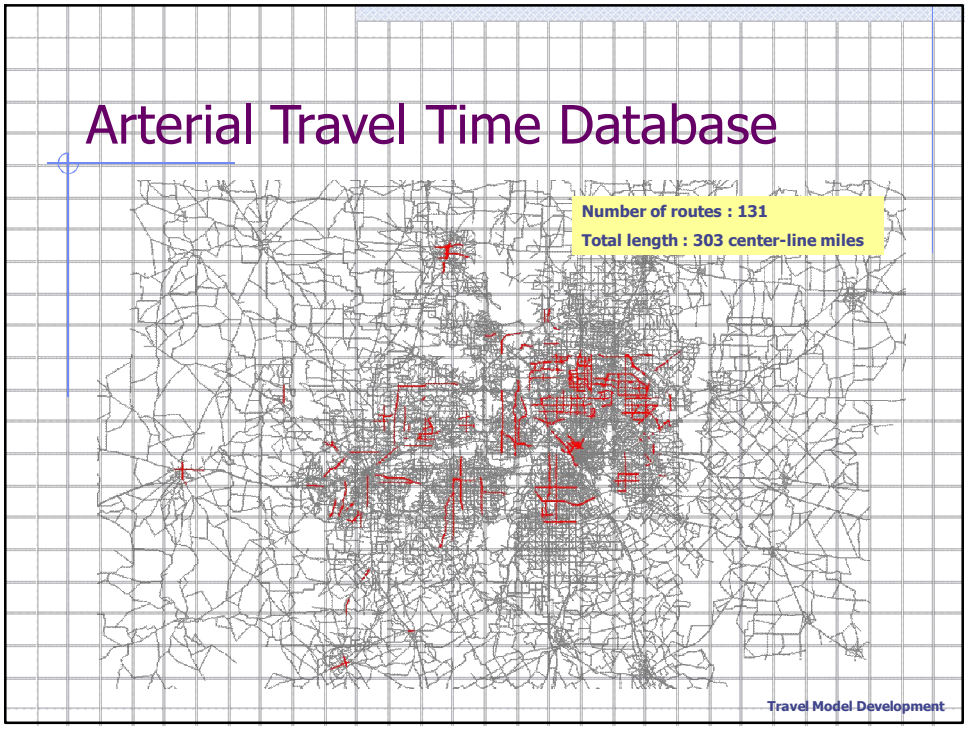


Travel Model Development

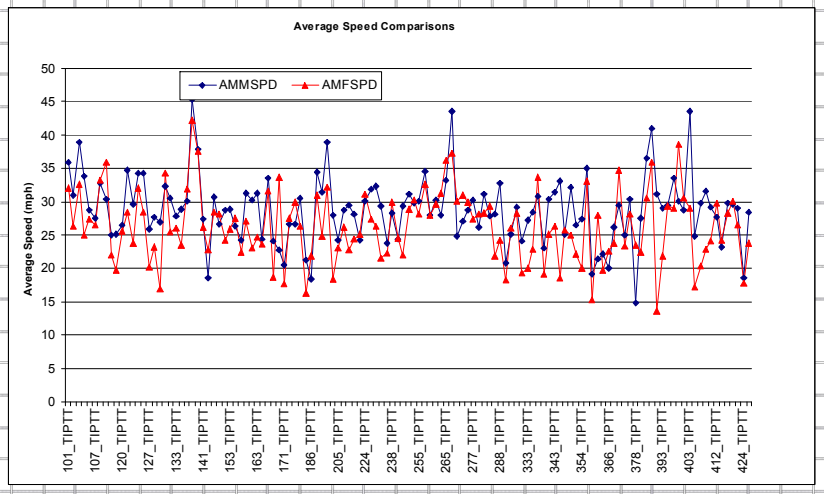
SkyComp Freeway PM Speeds



Arterial Travel Time Database

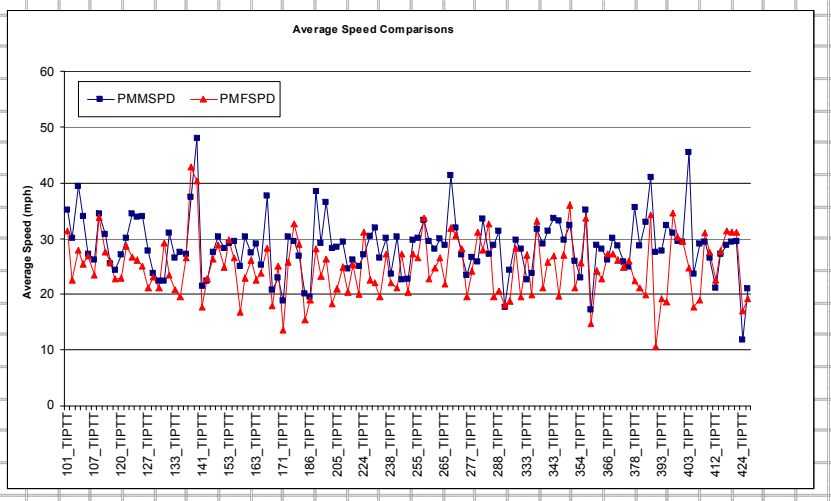


Arterial Speed Comparisons - AM



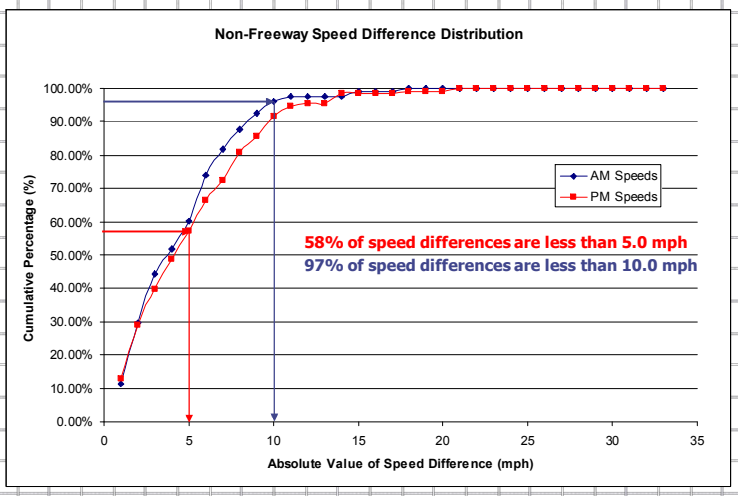
Travel Model Development

Arterial Speed Comparisons - PM



Travel Model Development

Arterial Speed Difference Distribution



Roadway Model

Feedback Convergence Criteria

Goals

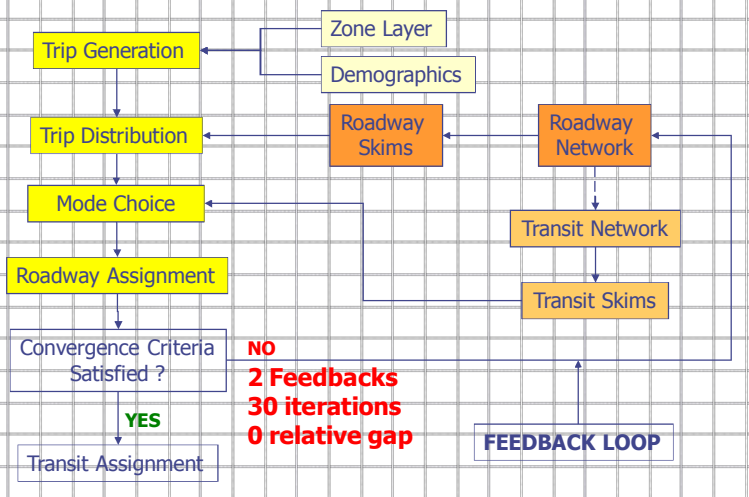
→ Provide the Capability to :

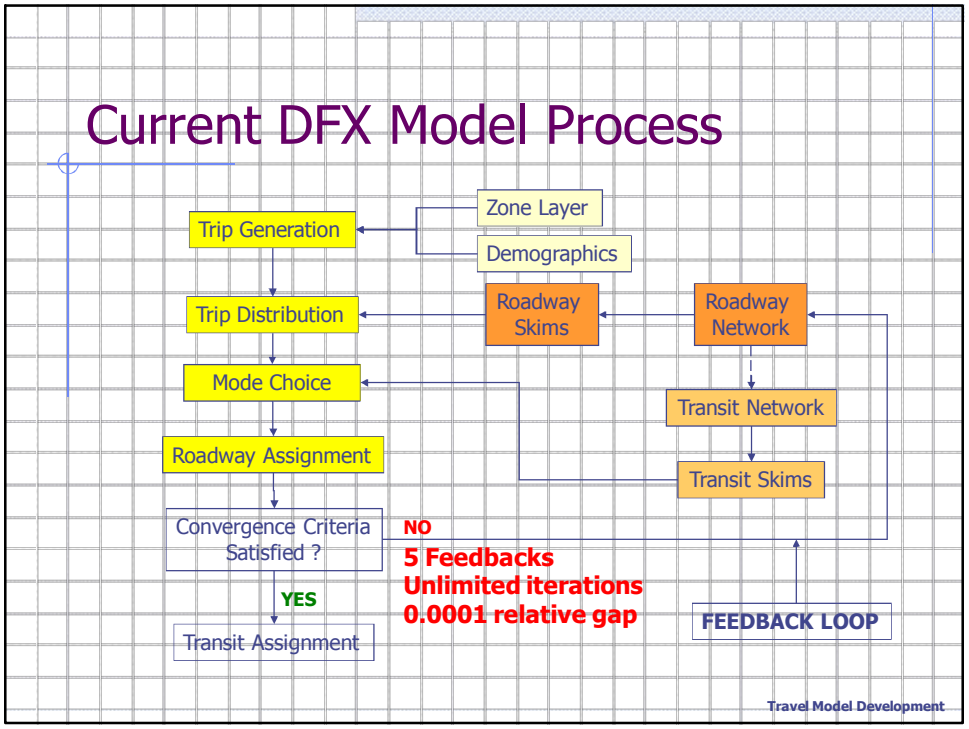
- perform consistent model runs
- reduce the model noise
- report model volume accuracy statements

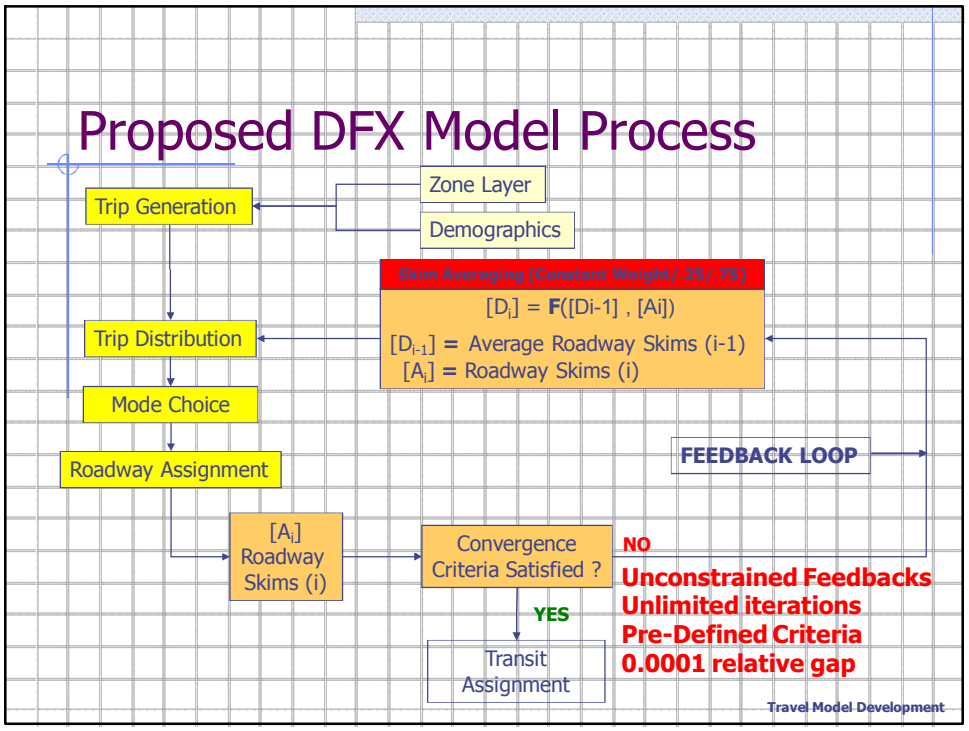
→ Define the Assignment Convergence Criteria as :

- a multi-dimensional criteria that is a function of the individual link volume and travel time in addition to the relative gap as defined in TransCAD

DFWRTM Model Process




Current DFX Model Process
Zone Layer
Trip Generation
Demographics
Trip Distribution
Roadway Skims
Roadway Network
Mode Choice
Transit Network
Roadway Assignment
Transit Skims
Convergence Criteria Satisfied ?
NO
5 Feedbacks
Unlimited iterations
0.0001 relative gap
YES
FEEDBACK LOOP
Transit Assignment
Travel Model Development


Proposed DFX Model Process
Zone Layer
Trip Generation
Demographics
Skim Averaging (Constant Weight .25/.75)
[Di] = F([Di-1] , [Ai])
[Di-1] = Average Roadway Skims (i-1)
[Ai] = Roadway Skims (i)
Trip Distribution
Mode Choice
FEEDBACK LOOP
Roadway Assignment
[Ai] Roadway Skims (i)
Convergence Criteria Satisfied ?
NO
Unconstrained Feedbacks
Unlimited iterations
Pre-Defined Criteria
0.0001 relative gap
YES
Transit Assignment
Travel Model Development

Proposed DFX Model Application

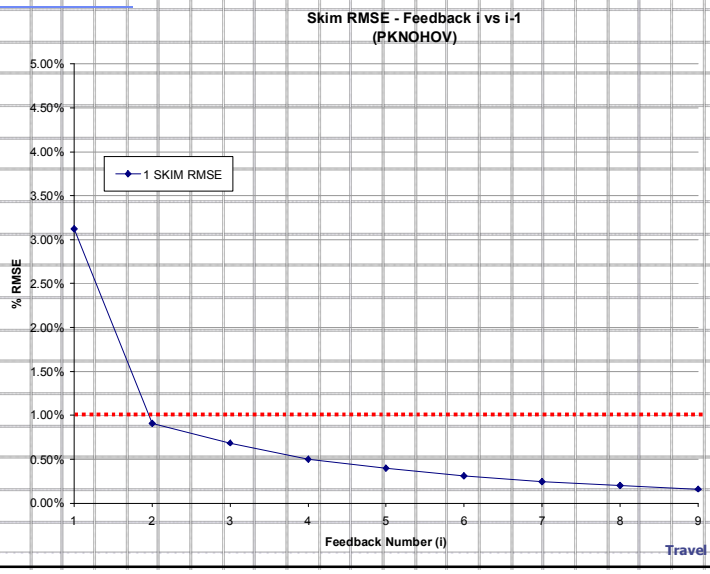
TransCAD

1. Number of iterations : Unlimited
2. Relative gap : 0.0001

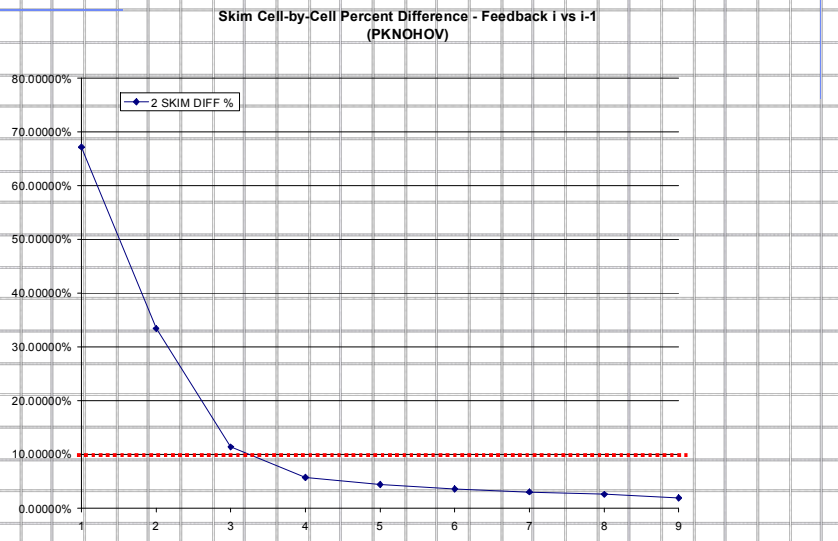
DFX

1. Number of feedbacks : min 3, max 10 (18-45 hours)
2. Skim Matrices RMSE : ≤ 1%
3. Maximum change in Skim Matrix cells : ≤ 10%
4. Link Volume RMSE : ≤ 2%
5. Link Volume Change :
   - ΔV F1 ≤ 15% one-lane capacity
   - ΔV F2 ≤ 20% one-lane capacity
   - ΔV F3 ≤ 25% one-lane capacity
   - ΔV F4 ≤ 25% one-lane capacity
   - ΔV F6 ≤ 25% one-lane capacity
   - ΔV F7 ≤ 50% one-lane capacity

Feedback Results - 2004

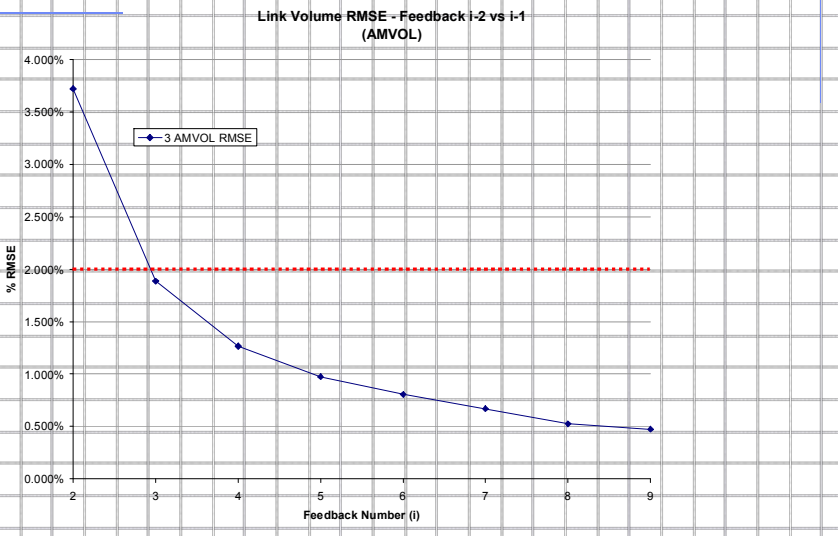


Feedback Results - 2004



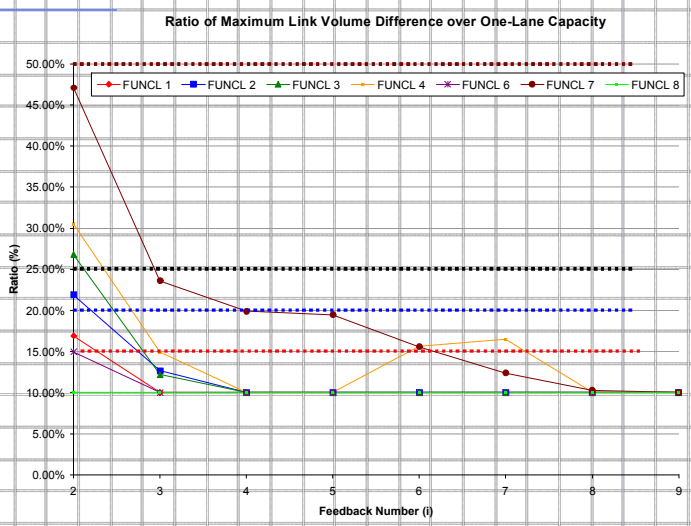
Travel Model Development

Feedback Results - 2004



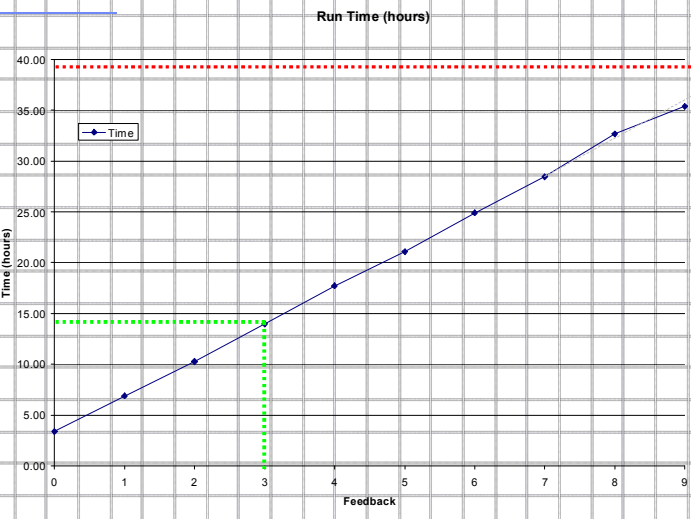
Travel Model Development

Feedback Results - 2004



Travel Model Development

Feedback Results - 2004



Travel Model Development